

ROOT GROWTH AND DEVELOPMENT IN RESPONSE TO CO₂ ENRICHMENT

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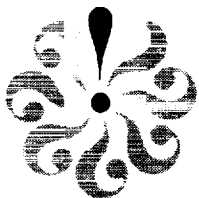
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Introduction

This report represents a brief summary of the results of the study. A manuscript based on these findings is currently in preparation and copies will be submitted to NASA when the paper is submitted this fall for publication in the scientific literature.

Statement of Purpose

A non-destructive technique (minirhizotron observation tubes) was used to assess the effects of CO₂ enrichment on root growth and development in experimental plots in a scrub oak-palmetto community at the Kennedy Space Center.

Potential effects of CO₂ enrichment on plants have global significance in light of concerns over increasing CO₂ concentrations in the Earth's atmosphere. The study at Kennedy Space Center focused on aboveground physiological responses (photosynthetic efficiency and water use efficiency), effects on process rates (litter decomposition and nutrient turnover), and belowground responses of the plants. Belowground dynamics are an exceptionally important component of total plant response but are frequently ignored due to methodological difficulties. Most methods used to examine root growth and development are destructive and, therefore, severely compromise results. Minirhizotrons allow non-destructive observation and quantification of the same soil volume and roots through time.

Our primary objective was to evaluate the effects of CO₂ enrichment on root length density and root phenology via minirhizotron observation tubes in an experimental project established by Ross Hinkle of Bionetics and Bert Drake of the Smithsonian Environmental Research Center.

Methods

The design of the experiment included 3 enclosed CO₂ enriched (700 ppm) plots, 3 enclosed plots with ambient CO₂ levels (350 ppm), and 3 non-enclosed plots. The plots were approximately 4.5 m², and the clear plastic chambers were open at the top. During mid-July 1992, 27 observation tubes were installed in and around the experimental plots. The clear butyrate tubes, with observation "windows" inscribed, were inserted into hand augered holes to a depth of about 1 meter at a 30° angle. Two tubes were installed into each plot; each tube entered the ground at the outside edge of the plot and extended underground to about the center of the plot. Five tubes were installed about a meter outside the CO₂ enriched plots, and four tubes were placed outside the reference plots (no chambers). These tubes were to allow an evaluation of possible belowground enrichment effects expressed beyond the boundaries of the experimental plots.

Immediately following installation, initial recordings of root images were obtained from all tubes. A specially constructed color video camera was inserted into the tubes and images were recorded on a super-VHS video recorder. Frequent recordings were impractical; thus, the decision was made to make subsequent recordings at approximately 3 to 4 month intervals. Additional recordings were obtained on 13 November, 1992, 9 March, 1993, 22 June, 1993, and 15 October, 1993. The images were digitized for analysis with ROOTS and CMAP software from Michigan State University. Root length densities per tube and over the soil profile were determined, and fine root turnover was computed.

Results

The preliminary results from the chambers clearly demonstrate the utility and

effectiveness of the minirhizotron technique at quantifying responses to CO₂ enrichment. Many studies have demonstrated that plants respond positively to CO₂ enrichment, and some of these have found increased root biomass. However, few of these studies have examined nonagricultural plants in the natural community (Rogers, H.H., G.B. Runion, and S.V. Krupa. 1994. *Environmental Pollution* 83: 155-189). Our data show substantially greater root length densities in the CO₂ enriched chambers. Total root length density increased in all chambers during the year and a half observation period due to growth and recovery of the vegetation, which had been cut at the start of the study. Each cohort of new roots was tracked during subsequent time periods and turnover determined. The greatest loss per cohort occurred during the period immediately following formation. The percentage of roots lost from one observation period to the next decreased steadily in the CO₂ enriched chambers, but generally stayed above 50% loss in the ambient chambers (except for the spring to summer period). Growing in a CO₂ enriched atmosphere appeared to cause a distinct shift in the vertical distribution of roots. In the CO₂ enriched chambers a bimodal distribution pattern with an increase in root mass below 81 cm depth, appeared to develop. Increased production results in greater resource demands by the plants that may be met by increased fine root proliferation in areas of higher resource availability. The deeper proliferation of fine roots in the CO₂ enriched chambers appears to occur around the top of the water table; thus, this may be a response to water stress. Root mass generally decreased with increasing depth throughout the ambient chamber profiles. CO₂ enrichment increased root proliferation, decreased root turnover, and altered the vertical allocation of carbon in the soil profile.

Presentations and Abstracts

Day, F.P. and E.P. Weber. 1993. Minirhizotron applications: CO₂ enrichment in a scrub oak-palmetto community in central Florida. Workshop on "Belowground Responses to Rising Atmospheric CO₂". University of Michigan Biological Station.

Day, F.P. and E.P. Weber. 1994. Effects of elevated CO₂ on root dynamics in a scrub oak-palmetto community in central Florida. Association of Southeastern Biologists Meeting. Orlando, Florida. (ASB Bulletin 41: 96).

Day, F.P. and E.P. Weber. 1994. Effects of elevated CO₂ on root length density, distribution and turnover in a scrub oak-palmetto community in central Florida. Ecological Society of America meeting. Knoxville, TN. (Bulletin of ESA 75(2): 50).

Publications

Day, F.P., E.P. Weber, C.R. Hinkle, and B. Drake. Effects of elevated CO₂ on root length density and distribution in a scrub oak-palmetto community in central Florida. Global Biology. In preparation.